CLAIMS

We claim:

1. A connector for electrically connecting to pads formed on a semiconductor device, comprising:

a substrate; and

a plurality of contact elements of conductive material formed on the substrate, each contact element including a base portion attached to the top surface of the substrate and a curved spring portion extending from the base portion and having a distal end projecting above the substrate, the curved spring portion being formed to curve away from a plane of contact and having a curvature disposed to provide a controlled wiping action when engaging a respective pad of the semiconductor device.

2. The connector of claim 1, wherein the plurality of contact elements are separated by a pitch of less than about 250 micron.

3. The connector of claim 1, wherein a first contact element of the plurality of contact elements has a curvature for providing a controlled wiping motion with a wiping distance of up to 50% of the respective pad to be engaged.

4. The connector of claim 1, wherein each of the plurality of contact element is in vertical alignment with a respective pad of the semiconductor device and engages the pad by the application of a vertical external biasing force.

5. The connector of claim 1, wherein the base portion and the spring portion of each contact element are formed as a contiguous structure using the same conductive material.

6. The connector of claim 1, wherein the base portion of the plurality of contact elements is formed using a first conductive metal and the spring portion of the plurality of contact elements is formed using a second conductive metal.

7. The connector of claim 5, wherein the spring portion of a first one of the plurality of contact elements is coated with a conductive material.

8. The connector of claim 5, wherein the plurality of contact elements is made from a material selected from the group of copper, copper alloy, small-grained copper-beryllium (CuBe) alloy, and a stainless steel/Cu/Ni/Au multilayer.

9. The connector of claim 1, wherein the spring portion of each contact element has an elastic working range on the order of an electrical path length of the contact element.

10. The connector of claim 1, wherein the plane of contact comprises the surface of the pads being contacted.

11. The connector of claim 1, wherein the connector is disposed to connect to pads formed on a semiconductor wafer which pads are formed with a pitch of less than or about 50 micron.

12. The connector of claim 1, wherein the connector is disposed to connect to pads of a land grid array device.

13. The connector of claim 1, wherein the connector is disposed to connect to solder balls formed on the semiconductor

device which solder balls are formed having a pitch of less than or about 250 micron.

14. The connector of claim 13, wherein the plane of contact comprises a plane tangent to the side surface of the solder balls being contacted.

15. The connector of claim 1, wherein the curved spring portion of each contact element comprises a first curved spring portion and each contact element further comprises a second curved spring portion positioned opposite to the first curved spring portion, the second curved spring portion extending from the base portion and having a distal end projecting above the substrate, the second curved spring portion being formed to curve away from the plane of contact and having a curvature disposed to provide a controlled wiping action when engaging a respective pad of the semiconductor device.

16. The connector of claim 15, wherein each contact element comprises two or more curved spring portions extending from the base portion, each of the curved spring portion having a distal end projecting above the substrate, being formed to curve away from the plane of contact, and having a curvature disposed to provide a controlled wiping action when engaging a respective pad of the semiconductor device.

17. The connector of claim 15, wherein the connector is disposed to connect to solder balls formed on the semiconductor device, the first curved spring portion and the second curved spring portion of each contact element engaging a respective solder ball on the side surface of the solder ball.

18. The connector of claim 15, wherein the first curved spring portion and the second curved spring portion projects above the substrate in a spiral configuration.

19. The connector of claim 15, wherein the distal end of first curved spring portion is facing the distal end of the second curved spring portion of a first contact element of the plurality of contact elements.

20. The connector of claim 15, wherein the first curved spring portion and the second curved spring portion of a first contact element of the plurality of contact elements are formed back-to-back with the respective distal ends facing outwardly from the base portion.

21. The connector of claim 1, wherein the plurality of contact elements comprises a first contact element and a second contact element, the first contact element having a mechanical property different than a mechanical property of the second contact element.

22. The connector of claim 21, wherein the first contact element includes a curved spring portion having a first elastic working range and the second contact element includes a curved spring portion having a second elastic working range, the second elastic working range being greater than the first elastic working range.

23. The connector of claim 21, wherein the first contact element includes a curved spring portion protruding a first distance above the top surface of the substrate and the second contact element includes a curved spring portion protruding a

second distance above the top surface of the substrate, the second distance being greater than the first distance.

24. The connector of claim 21, wherein the first contact element includes a curved spring portion requiring a first contact force and the second contact element includes a curved spring portion requiring a second contact force, the second contact force being greater than the first contact force.

25. The connector of claim 24, wherein the first contact element includes one or more curved spring portions extending from the base portion and the second contact element includes a plurality of curved spring portions extending from the base portion, the second contact element having more curved spring portions than the first contact element.

26. The connector of claim 21, wherein the first contact element is made of a first metal composition and the second contact element is made of a second metal composition different than the first metal type.

27. The connector of claim 21, wherein the first contact element is made of a metal layer having a first thickness and the second contact element is made of a metal layer having a second thickness different than the first thickness.

28. The connector of claim 1, wherein the plurality of contact elements comprises a first group of contact elements and a second group of contact elements, the first group of contact elements being separated by a first pitch and the second group of contact elements being separated by a second pitch larger than the first pitch.

29. The connector of claim 1, wherein the plurality of contact elements comprises a first contact element and a second contact element, the first contact element having an electrical property different than an electrical property of the second contact element.

30. The connector of claim 29, wherein the first contact element includes a curved spring portion having a first resistance and the second contact element includes a curved spring portion having a second resistance, the second resistance being greater than the first resistance.

31. The connector of claim 29, wherein the first contact element includes a curved spring portion having a first impedance and the second contact element includes a curved spring portion having a second impedance, the second impedance being greater than the first impedance.

32. The connector of claim 29, wherein the first contact element includes a curved spring portion having a first inductance and the second contact element includes a curved spring portion having a second inductance, the second inductance being greater than the first inductance.

33. The connector of claim 29, wherein the first contact element includes a curved spring portion having a first current carrying capability and the second contact element includes a curved spring portion having a second current carrying capability, the second current carrying capability being greater than the first current carrying capability.

34. The connector of claim 1, further comprising one or more conductive ground planes formed on or embedded in the substrate, the plurality of conductive ground planes being in proximity to but electrically isolated from a selected one of the plurality of contact elements.

35. The connector of claim 34, wherein a distance between the one or more conductive ground planes and the selected one of the plurality of contact elements is varied to establish a desired impedance for the contact element.

36. The connector of claim 34, wherein the one or more conductive ground planes are electrically connected to a first contact element of the plurality of contact elements.

37. The connector of claim 34, wherein the plurality of contact elements comprises a first contact element and a second contact element to be connected to pads forming a pair of differential signals, a first distance between the one or more conductive ground planes and the first contact element and a second distance between the one or more conductive ground planes and the second contact element are varied to establish a desired impedance for the contact elements.

38. The connector of claim 1, further comprising an electrical circuit formed on or within the substrate, the electrical circuit being electrically connected to at least one of the plurality of contact elements.

39. The connector of claim 38, wherein the electrical circuit is formed by one or more metal layers embedded within the substrate.

40. The connector of claim 39, wherein a first contact element of the plurality of contact elements is electrically connected to the electrical circuit, the first contact element and the electrical circuit being formed using a metal layer of the same type.

41. The connector of claim 1, further comprising a thermally conductive plane formed within the substrate and electrically isolated from each of the plurality of contact elements.

42. The connector of claim 41, wherein the thermally conductive plane comprises a copper plane and is formed spaced apart from each of the plurality of contact elements for electrical isolation.

43. The connector of claim 41, wherein the thermally conductive plane comprises a filed epoxy and is formed in intimate contact with a first one of the plurality of contact elements.

44. The connector of claim 1, wherein the plurality of contact elements comprises at least one coaxial contact element, the coaxial contact element comprising:

a first contact member including a first base portion and a first curved spring portion extending therefrom, the first base portion defining an opening; and

a second contact member including a second base portion and a second curved spring portion extending therefrom, the second base portion being formed within the opening defined by the first base portion,

wherein the first contact member is electrically isolated from the second contact member.

45. The connector of claim 1, wherein each contact element further includes a conductive adhesion portion on which the base portion is attached, the conductive adhesion portion being attached to the top surface of the substrate and has an area greater than the area of the base portion.

46. A connector for electrically connecting to solder balls of a ball grid array device, comprising:

a substrate; and

a plurality of contact elements of conductive material formed on the substrate, each contact element including a base portion attached to the top surface of the substrate and a plurality of curved spring portions extending from the base portion, each curved spring portion having a distal end projecting above the substrate,

wherein the plurality of curved spring portions of each contact element are formed to engage the side surface of a respective solder ball of the ball grid array device, the curved spring portions being formed to curve away from the plane of contact and having a curvature disposed to provide a controlled wiping action when engaging the respective solder ball of the ball grid array device.

47. The connector of claim 46, wherein the plane of contact comprises a plane tangent to the side surface of the solder balls being contacted.

48. The connector of claim 46, wherein the base portion and the plurality of curved spring portions of each contact element

are formed as a contiguous structure using the same conductive material.

49. The connector of claim 46, wherein the base portion of the plurality of contact elements is formed using a first conductive metal and the spring portion of the plurality of contact elements is formed using a second conductive metal.

50. The connector of claim 48, wherein the spring portion of a first one of the plurality of contact elements is coated with a conductive material.

51. The connector of claim 48, wherein the plurality of contact elements is made from a material selected from the group of copper, copper alloy, small-grained copper-beryllium (CuBe) alloy, and a stainless steel/Cu/Ni/Au multilayer.